Title: POWER SEMICONDUCTOR DIE ATTACH PROCESS USING CONDUCTIVE ADHESIVE FILM

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RELATED APPLICATIONS

This application relates to and claims the filing date of United States Provisional Application Serial No. 60/167,456 (IR-1773 PROV (2-2141)), filed November 24, 1999.

BACKGROUND OF THE INVENTION

This invention relates to semiconductor devices and more specifically relates to a novel process for the attachment of power semiconductor die to a thermally and/or electrically conductive support.

Power semiconductor die such as diodes, MOSFETs, IGBTs and the like are normally attached to conductive lead frames or other substrates by electrically conducting materials such as epoxies, thermoplastics, solders and the like or by electrically insulative materials if electrical isolation is desired. This process is carried out sequentially for individual die, after die singulation from a wafer and is time consuming.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with the invention adhesive films which may be electrically conductive or insulative are used as the die attach material for power semiconductors. Further, such adhesive films are attached to power semiconductor wafers before the die

singulation stage.

Adhesive films are now used to bond low power integrated circuits to lead frames. In accordance with the invention, electrically conductive or insulative adhesive films are used to bond power semiconductors to substrates/lead frames.

Adhesive films in the prior art are pre-cut and placed onto a substrate before the placement of die on the film. The resultant substrate/film/die assembly is then partially heat treated to promote adhesion between die/lead frame. In accordance with the invention, the adhesive film is placed onto the power semiconductor wafer before the die singulation stage. The wafer/adhesive film stack is then sawn using conventional singulation methods, producing die with the adhesive film pre-attached. The sawn die/film stack is then placed onto a substrate/lead frame before re-activating the adhesive via heat treatment to promote bonding and complete the curing.

There are a number of benefits provided by the invention. Thus, conventional power semiconductor die attach involves use of epoxy or solder type adhesives in paste or liquid form. These materials often overspill from the edge of the die onto the substrate/lead frame during die bonding. This overspill limits the size of die that can be placed on the lead frame/substrate. By using an adhesive film, such overspill is eliminated. Larger die can then be placed in a package of a given size. Bond line thickness is also set by the adhesive film thickness and will be constant. Voids in the bond will also be absent.

Pre-bonding electrically conductive or (electrically isolating) adhesive film onto the power semiconductor wafer before die singulation also removes the requirement of an extra pick and place stage during assembly. Manufacturing equipment costs and cycle times are therefore reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 and 2 are top and side views respectively of a prior art die attach.

Figure 3 and 4 are top and side views respectively of a power semiconductor die attached to a substrate by a conductive adhesive film.

Figure 5 is a perspective diagram of a large area adhesive film and a semiconductor device wafer before singulation.

Figure 6 is a perspective diagram of Figure 5 after adhesion.

Figure 7 shows one die/film stack singulated from the assembly of Figure 6 before attachment to a substrate.

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Figure 8 shows the assembly of Figure ~~8~~ 7 after heat cure and bonding.

Figure 9 shows the process of the invention as applied to a die-on-die assembly.

Figure 10 shows the process of the invention as applied to a side-by-side assembly of die on a common substrate.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Figures 1 and 2 show a prior art power semiconductor die 10 and a conductive substrate 12 to which it is attached by a solder or epoxy attach material 11. Note that material 11 conventionally overspills, thereby limiting the maximum size of the die on a substrate of given area.

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Figure 3 and 4 show the die 10 of Figures 1 and 2 where a thin, flexible adhesive film 13 is used to bond the die 10 and substrate ~~11~~ 12. Film 13 is electrically conductive or may be insulative, and is heat curable. The use of such film is seen in Figures 3 and 4 to eliminate overspill, thus enabling a larger area die 10 on the substrate 11 of same area as that of Figures 1 and 2.

The novel process of the invention is shown in Figures 5 to 8. Figure 5 shows

a semiconductor device wafer 21 which contains a large number of identical power semiconductor die which are simultaneously processed in a conventional manner. Thus, the wafer can contain hundreds of identical vertical conduction power MOSFET die which have P/N junctions in their top surface, conventionally covered by a conductive source electrode and a bottom conductive drain electrode. The die of the wafer are singulated by sawing the wafer with conventional sawing apparatus. The individual die are then to be mounted on a lead frame or other substrate by soldering or epoxy bonding the drain electrode of the die to the substrate.

In accordance with the invention, an adhesive film 20 is cut to the size of the wafer, which can have a typical diameter of about 6 inches.

Film 20 is preferably a polyimide film such as that know as a "KAPTON" film which is frequently used in PC boards, "flex" circuits, for electrical winding insulation and the like. The Kapton polyimide is an excellent insulator. The wafer 21 and film 20 are then laid atop one another and are preheated to promote adhesion, but to not fully cure the film 20.

Thereafter, and as schematically shown in Figure 6 the film 20 and wafer 21 are simultaneously sawn at cut lines 22 into separate die. A conventional frame or support keeps the separated film/die stacks in place and the stacks are then placed into a conventional pick and place device so that the singulated devices can be picked up and carried to a location to be mounted on respective heated lead frames or substrates in an automated manner.

Thus, as shown in Figure 7 the die/film stack 21/20 can be picked up and placed atop a respective substrate 11 with a conventional pick and place apparatus. Pressure is preferably applied to press the stack 21/20 onto the surface of the pre-heated substrate 11.

Thereafter, the die/film stack 21/20 and substrate 11 are heated to about 260°C to fully heat cure film ~~21~~ 20 to form a bond to the substrate 11.

The structure of figures 7 and 8 can also be carried out to form die-on-die

packages (Figure 9) or side-by-side die packages (Figure 10). Thus, in Figure 9, two identical die 30 and 31 or die with un-equal dimensions having adhesive layers 20 and semiconductor die 21 may be mounted with die 31 atop die 30. Die 30 and 31 may be diverse devices, for example, a MOSFET and a Schottky diode respectively and may be of different sizes or areas. Alternatively, die 31 can be an integrated circuit.

Further, layers 20 in Figure 9 can be a suitable electrically conductive adhesive film to allow back-to-back connection of die 30 and 31.

As shown in Figure 10, the die 30 and 31 may contain a MOSFET and an IC respectively (die 21).

Other film which can be used for film 20 includes thermoplastic adhesive paste such as Alpha Metals 383G (RHS) and UH2W-E polyimide film (LHS).

Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. It is preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.